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ABSTRACT

Several ways of structuring the early trials of a complex concept formation task were compared. Training trials were divided into two segments: (1) an asynchronous segment with one relevant and one irrelevant cue held constant while one relevant and one irrelevant cue varied and (2) a synchronous segment with all cues free to vary. The asynchronous segment was further divided into two parts in which (1) the more relevant cue was free to vary and (2) the less relevant cue was free to vary. The four possible orders of presenting the conditions were compared with each other and with a control group in which only synchronous segments were given. Eleven people in each of two experimental groups and one control group were given 160 presentations of the McHale-Stolurow (1962) task in five blocks of 32 trials. The first two blocks were training trials; the last three were the task trials. Performance on asynchronous trials was superior to performance on synchronous trials during training although no significant difference appeared on the task trials. There was no difference due to the ordering of asynchronous and synchronous blocks during training. During asynchronous trials, it proved better to present the more relevant cue varying first. (KB)

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THE EFFECTS OF SEQUENCE AND STRUCTURE ON COMPLEX CONCEPT FORMATION

Daniel J. Davis

TECHNICAL REPORT NO. 4

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The Effects of Sequence and Structure
on Complex Concept Formation

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BACKGROUND

Consider a concept formation task in which there are two cues that are relevant to the solution and two cues that are not. Also, of the two cues that are relevant, one is more relevant than the other. That is, solutions based only on the more relevant cue will be closer to the correct solution than those based only on the less relevant one.

For such a task it has been found that subjects can learn the relevance of stimulus parameters simultaneously. Through informational feedback with knowledge of results they learn to ignore the irrelevant cues and to correctly weight and combine the relevant cues into a complex concept (Azuma, 1960, McHale and Stolurow, 1962).

For a similar task in which there was one relevant cue and two irrelevant cues, Detambel and Stolurow (1956) showed that sequencing is an important factor in the effectiveness of training. In particular, great improvement results when the following conditions are met:

a. When the value of the relevant cue changes on adjacent trials, the values of the irrelevant cues remain fixed.

b. When the value of one or both of the irrelevant cues changes, the value of the relevant cue remains fixed.

The above conditions determined what they called "asynchronous trials" as compared to "synchronous trials" in which all cues were free to vary simultaneously.

In this study several ways of structuring and sequencing the early trials of a complex concept formation task were compared. The comparison was made on the basis of transfer to later trials which were completely unstructured or synchronous.

The training trials were divided into two main segments:

1. Asynchronous segment (A)--one relevant and one irrelevant cue were held constant while one relevant and one irrelevant cue were free to vary.

2. Synchronous segment (S)--all cues were free to vary.

The asynchronous segment was divided into two parts:

1. A--MAX. --The more relevant cue was free to vary.

2. A--MIN. --The less relevant cue was free to vary.

The four possible orders of presenting the above conditions were compared with each other and with a control condition in which only synchronous trials were given during training. The purpose of this was to obtain answers to the following questions:

1. <u>What is the effect of adding the asynchronous trials?</u>

Based on the study of Detambel and Stolurow it is expected that during training the asynchronous groups should do better, but it is not at all certain that they will transfer to the synchronous situation. Whether they do or not

would seem to depend on how they form the concept. If they operate on each cue independently and then combine them, there should be positive transfer. The reason for this is that on asynchronous trials they can direct all their attention to one cue at a time and later try to combine them. If, on the other hand, they use relationships between the cues, the asynchronous trials should be of no help.

2. What is the best order of presentation of the asynchronous (A) and synchronous (S) training trials?

It is expected that the order S-A is better than A-S. In the former case, the subject is familiarized with the situation to which he must eventually transfer. Therefore, on the A-trials he has a reference on which to base his hypotheses.

3. During the asynchronous trials is it better to present the more relevant cue varying first?

Based on some preliminary work there are indications that the MAX-MIN order is better than MIN-MAX. The subject can account for more of the variation of the solution during the MAX. condition, and, it seems easier to build a complex concept when most of the variation is explained by the main construct.

METHOD

Task

The task used is the same as the one used by McHale and Stolurow (1962). Since the materials used and method of presentation are the same, they are not described in detail here. The stimuli consist of a red cross and a green cross presented in 2.5 inch by 2.5 inch squares. Each cross can appear in one of four horizontal and four vertical positions. The two relevant cues are the

horizontal positions of the crosses and the irrelevant cues are their vertical positions. The concept 'k' is defined as follows:

$$k = \frac{2x' + x''}{3}$$

where: x' is the horizontal position of the red cross
x'' is the horizontal position of the green cross
The positions are valued 3, 6, 9, and 12.

In this case the position of the red cross is weighted twice as much as that of the green cross.

The cue values for each stimulus of the asynchronous blocks are shown in Appendix A. The values of the fixed cues during each condition as well as the trial to trial values of the varying cues were chosen according to a table of random numbers. Since there were 16 trials and only 15 positions available for each condition, one stimulus appeared on two separate trials (for the MAX. condition, [6, 6] appeared on trials three and eight; for the MIN. condition [6, 12] appeared on trials two and eight).

The synchronous blocks are identical to those used by McHale and Stolurow (1962). The intercorrelations of the cues and 'k' are shown in Appendix B. On the synchronous blocks the stimuli were chosen so that the correlations of the irrelevant cues (y', y'') with 'k' were as close to zero as possible. Also, every combination of x' and x'' appeared once in each block of 16 trials so that the correlation of these cues was zero.

Procedure

Each group was given 160 presentations in five blocks of 32 trials. The first two blocks were the training trials and the last three were the task trials.

The 32 asynchronous trials consisted of 16 A-MAX trials and 16 A-MIN trials. The procedure is outlined in Table 1.

Table 1
Experimental Procedure

Group	Training Conditions (1-32)	Training Conditions (33-64)	Task Cond. (65-160)
Exp. 1	A(MIN-MAX)	S	S
Exp. 2	A(MAX-MIN)	S	S
Exp. 3	S	A(MIN-MAX)	S
Exp. 4	S	A(MAX-MIN)	S
Control	S	S	S

Each subject read the instructions shown in Appendix C. The following additional instruction was given verbally to each experimental group prior to the two types of asynchronous trials: "On the following presentations the red (green) cross will always appear in the same position. Therefore, changes in the value of 'k' will be caused by changed in the position of the green (red) cross."

After the second and the final blocks the subjects were given four test stimuli and asked to explain how they arrived at their answers.

Subjects

Subjects were taken from the Introductory Psychology course at the University of Illinois. There were 11 female subjects in each experimental

treatment. The control group consisted of eight females and three males chosen from a group which used identical materials except for the asynchronous training.

RESULTS

The Pearson product-moment correlations ("criterialities") of each subject's scores with each of the criteria (k, x', x", y', y") were calculated for the synchronous blocks and the two parts of the asynchronous block. For the purposes of analysis these were converted to Z' scores which are distributed in approximately normal form: (See Edwards,1960)

The average criterialities for each group are given in Appendix D. These are used in the graphs which follow, and were obtained by averaging the Z' scores and reconverting to a correlation.

The correlation of each subject's score with the correct score (k-criteriality) is used as the performance measure. The average k-criterialities are plotted in Fig. 1. The values for the asynchronous block are the averages of the values for the A-MAX. and A-MIN. portions. Part A of the figure shows the curves for the two A-S groups (Exp. I and Exp. II) and the control group while Part B shows the curves for the S-A groups (Exp. III and Exp. IV) and the control group.

Analysis of Task Trials

The experimental groups were compared using a 2 x 2 x 3 factorial design. The first factor involves the S-A vs A-S order comparison. The

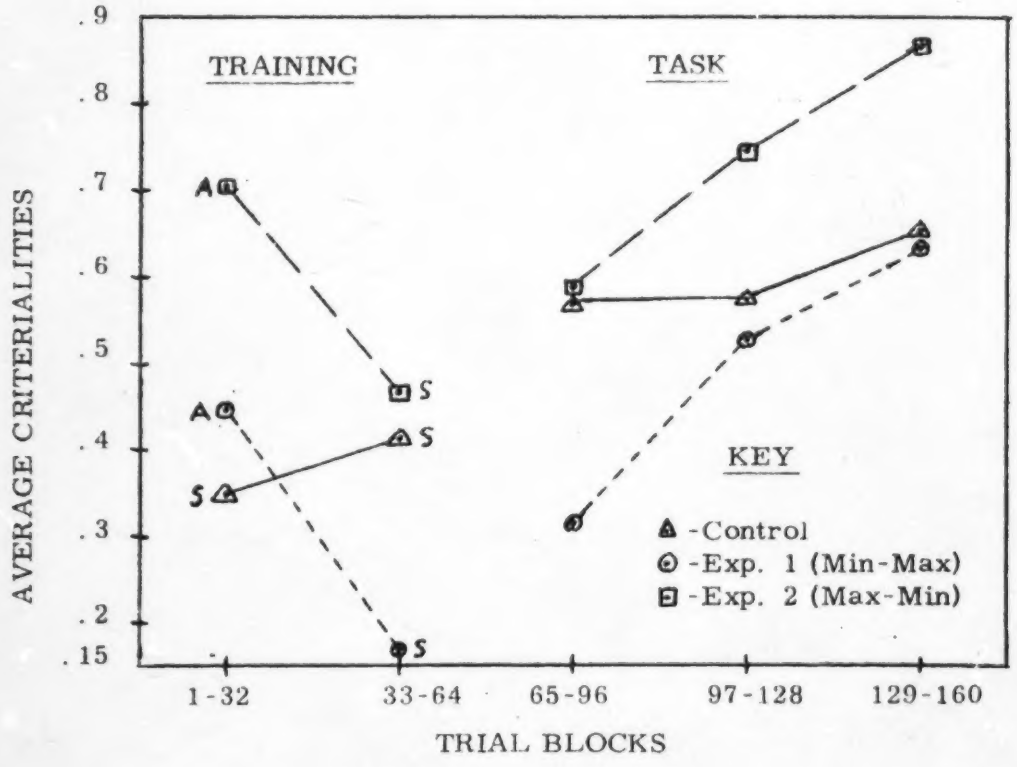

Figure 1 A: Average Criterialities of the (A-S) Groups and the Control Group

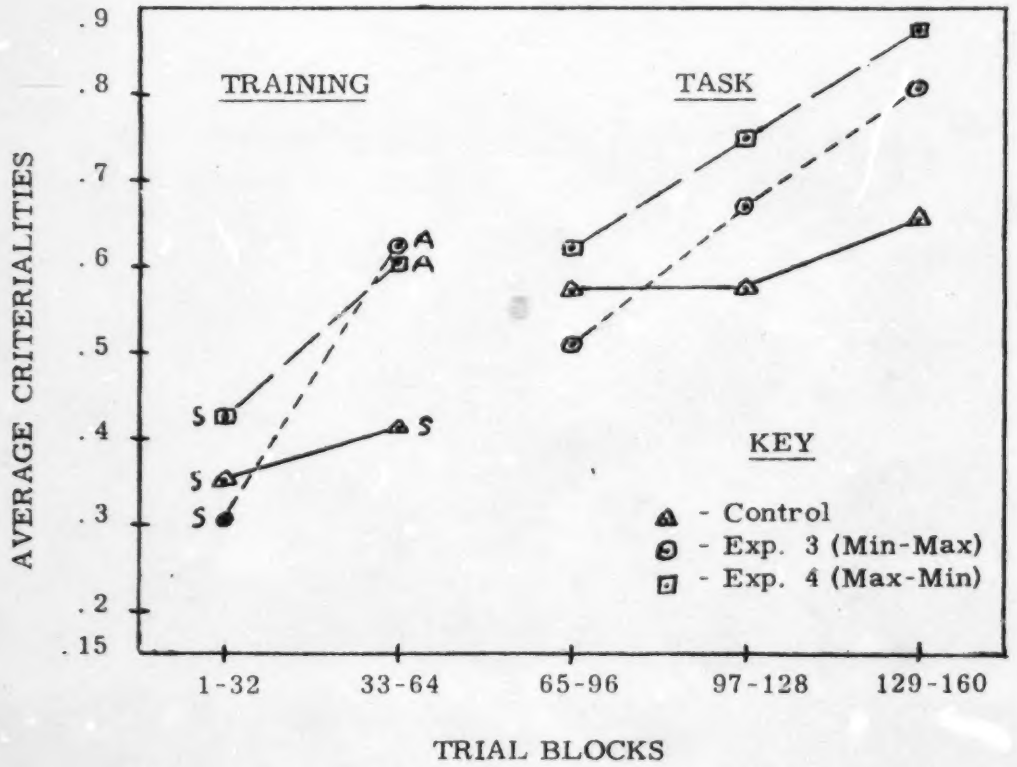

Fig. 1B. Average Criterialities of The (S-A) Groups and the Control Group

third involves the blocks factor which has the task blocks as its three levels. The analysis followed the procedure of Winer (1962) for a three-factor experiment with repeated measures on one factor.

The results are summarized in Table 2. No interactions were significant while the main effects of [illegible]-[illegible]IN order and trial blocks were significant.

The plan for comparing the control group with the experimental groups was as follows: first, the five groups were compared in a 5 x 3 repeated measures design on the three task blocks. If the overall group difference were significant,the control group would have been compared individually with each of the experimental groups. However, this was not the case as seen in Table 3. The group difference was not significant and the individual comparisons could not be made due to logical considerations

This analysis indicates the following:

1. There was an improvement in performance over the task trials for all groups.

2. There were no differences in the rate of learning among the groups.

3. The asynchronous training did not significantly improve performance.

4. It did not matter when the asynchronous training was given (i.e., initially or after a block of synchronous trials).

5. The groups who paid attention to the maximally pertinent cue first performed better than those who did not.

Analysis of Training Trials

Two comparisons were made among the experimental groups: first, performance on the asynchronous block was compared with performance on

Table 2

Summary of Analysis of Variance of Task Scores for the Experimental Groups[a]

Source	SS	d.f	MS	F
Between Subjects	33.383	43		
A(S-A Order)	.858	1	.858	1.188
B(MAX-MIN Order)	3.180	1	3.180	4.404[b]
A x B	.447	1	.447	.619
Subj. within groups	28.898	40	.722	
Within Subjects	18.112	88		
C(Trial Blocks)	6.781	2	3.391	24.396[c]
A x C	.050	2	.025	.180
B x C	.162	2	.081	.583
A x B X C	.021	2	.021	.079
C x Subj. within a groups	11.098	80	.139	

[a]The k-criterialities were transformed to Fisher-Z scores for this analysis.

[b]$F_{.95}(1, 40) = 4.08$

[c]$F_{.99}(2, 80) = 4.92$

Table 3

Summary of Analysis of Variance
of Task Scores for the
Experimental and Control Groups

Source	SS	d. f.	MS	F
Between Subjects	40.619	54		
A (Groups)	5.068	4	1.267	1.772
Subj. Within Groups	35.751	50	.715	
Within Subjects	19.309	110		
B (Trial Blocks)	6.051	2	3.026	22.917[a]
A x B	1.073	8	.134	1.015
B x Subj. within grps.	13.185	100	.132	

[a] $F_{.99}(2, 100) = 4.86$.

the synchronous block; second, within the asynchronous block, the A-MIN and A-MAX trials were compared (see Fig. 2).

Each comparison was accomplished in a 2 x 2 x 2 factorial design with repeated measures on the third factor. The first two factors represent the arrangement of the experimental groups while the third factor represents the synchronous vs. asynchronous comparison in the first case and the A-MAX vs A-MIN comparison in the second case.

The summary for the S vs A comparison is given in Table 4. No interactions were significant while the main effects of MAX-MIN order and S vs. A comparison were significant.

The summary table for the A-MAX vs. A-MIN comparison is given in Table 5. The triple interaction was significant. Therefore, the comparison was made separately for each experimental group. The summary of this analysis is shown in Table 6. The performance difference on the two types of asynchronous trials was significant for Exp. -1 and Exp. -2 but not Exp. -3 and Exp. -4.

A partial check on the equivalence of the groups prior to training was made by comparing Exp. -3, Exp. -4 and the control group on Block 1 performance (see Fig. 1.). Since each of these groups received identical treatment prior to as well as on this block, any difference in their performances here would indicate that extra-experimental influences were affecting later observed differences.

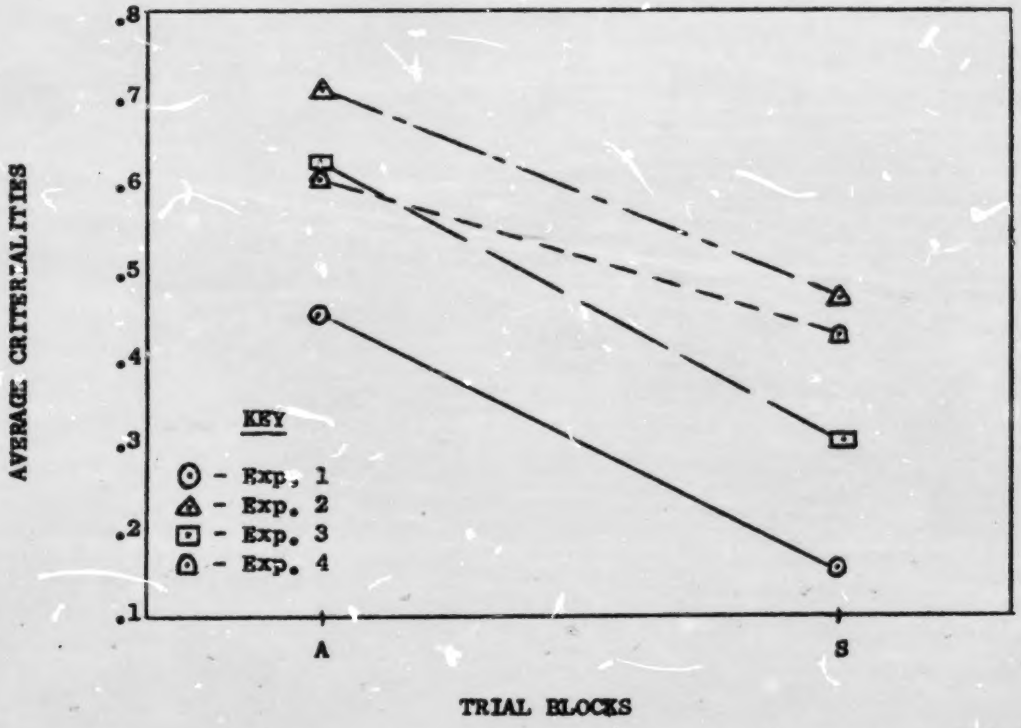

Fig. 2A. Synchronous vs. Asynchronous Performance on the Training Trails

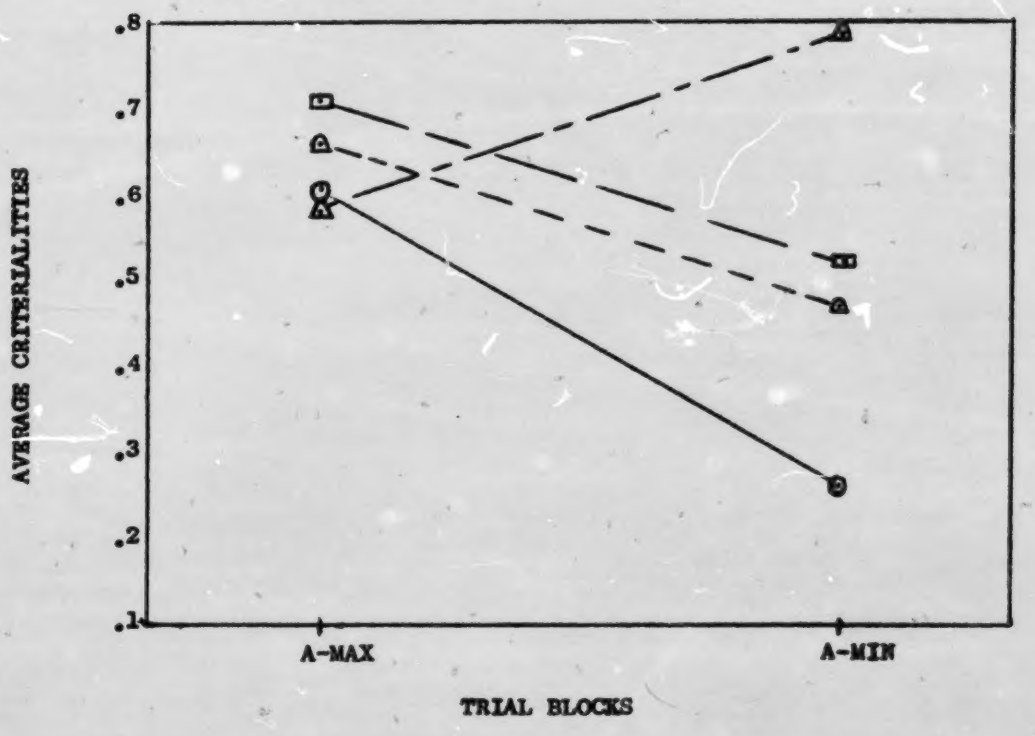

Fig. 2B. A-MAX vs. A-MIN Performance on the Training Tasks

Table 4

Summary of Analysis of Variance
For Synchronous vs. Asynchronous
Performance on the Training Trials[a]

Source	SS	d. f.	MS	F
Between Subjects	8.045	43		
A(S-A Order)	.025	1	.025	.154
B(MAX-MIN Order)	.893	1	.893	4.895[b]
A x B	.639	1	.639	3.944
Subj. within groups	6.488	40	.162	
Within Subjects	5.568	44		
C(S vs. A)	2.355	1	2.355	30.584[c]
A x C	.009	1	.009	.117
B x C	.045	1	.045	.584
A x B x C	.095	1	.095	1.234
C x Subj. within grps	3.064	40	.077	

[a]The Z' score for the asynchronous trials is the average Z' score for the A-MAX and A-MIN blocks.

[b]$F_{.95}(1, 40) = 4.08$

[c]$F_{.99}(1, 40) = 7.31$

Table 5

Summary of Analysis of Variance
For A-Max. vs. A-Min. Performance
on the Training Trials

Source	SS	d. f.	MS	F
Between Subjects	13.217	43		
A(S-A Order)	.004	1	.004	.013
B(MAX-MIN Order)	.537	1	.537	1.878
A x B	1.229	1	1.229	4.297
Subj. within groups	11.447	40	.286	
Within Subjects	10.115	44		
C(A-MIN vs. A-MAX)	.516	1	.516	2.851
A x C	.434	1	.434	1.845
B x C	1.026	1	1.026	5.669[a]
A x B x C	.905	1	.905	4.448[a]
C x Subj. within groups	7.234	40	.181	

[a] $F_{.95}(1.40) = 4.08$

Table 6

Summary of Analysis of Simple Effects for A-Min. vs. A-Max. Performance on the Training Trials[a]

Source	SS	d. f.	MS	F
Within Subjects	10.115	44		
C at A_1B_1 (MIN-MAX, S)	1.024	1	1.024	5.657[b]
C at A_1B_2 (MAX-MIN, S)	.906	1	.906	5.006[b]
C at A_2B_1 (S, MIN-MAX)	.518	1	.518	2.860
C at A_2B_2 (S, MAX-MIN)	.432	1	.432	2.386
C x Subj. within groups	7.234	40	.181	

[a] See Table 5 for basic analysis relating to triple order interaction and explanation of symbols. See Fig. 2B for graph.

[b] $F_{.95}(1, 40) = 4.08$

The method of analysis follows the procedure of Winer (1962, p. 65) and is summarized in Table 7. Although there was an overall significant difference for the five groups, there were no significant differences among the three groups which received identical treatment.

The analysis of the training trials indicates that:

1. Performance on the A-block was highly superior to performance on the S-block regardless of the order in which they were given.

2. The MAX-MIN groups performed better than the MIN-MAX groups.

3. The A-MAX vs. A-MIN comparison was different for the various experimental groups. Exp. -1 performed significantly better on the A-MAX trials while Exp. -2 performed significantly better on the A-MIN trials. Both Exp. -3 and Exp. -4 performed better on the A-MAX trials but the difference was not significant. (Fig. 2B).

4. Exp. -3, Exp. -4 and the control group can be considered identical in terms of initial performance on this task.

Cue Criterialities

The average cue criterialities for each of the groups are plotted in Figures 3 to 7. Also plotted in each figure are the k-criterialities. The value for each cue on the asynchronous blocks was taken from the portion (A-MAX or A-MIN) on which that cue was free to vary.

Table 7

Summary of Analysis of Variance
For the Experimental Groups
and the Control Group on the First Trial Block

Source	SS	d.f.	MS	F
Treatment	2.151	4	.538	5.38[a]
Exp. 3 vs Exp. 4	.111	1	.111	1.11[b]
Exp. 3 vs Control	.014	1	.014	.14
Exp. 4 vs Control	.046	1	.046	.46
Error	5.000	50	.100	
Total	7.150	54		

[a] $F_{.99}(4, 50) = 3.74$

[b] $F_{.75}(1, 50) = 1.35$

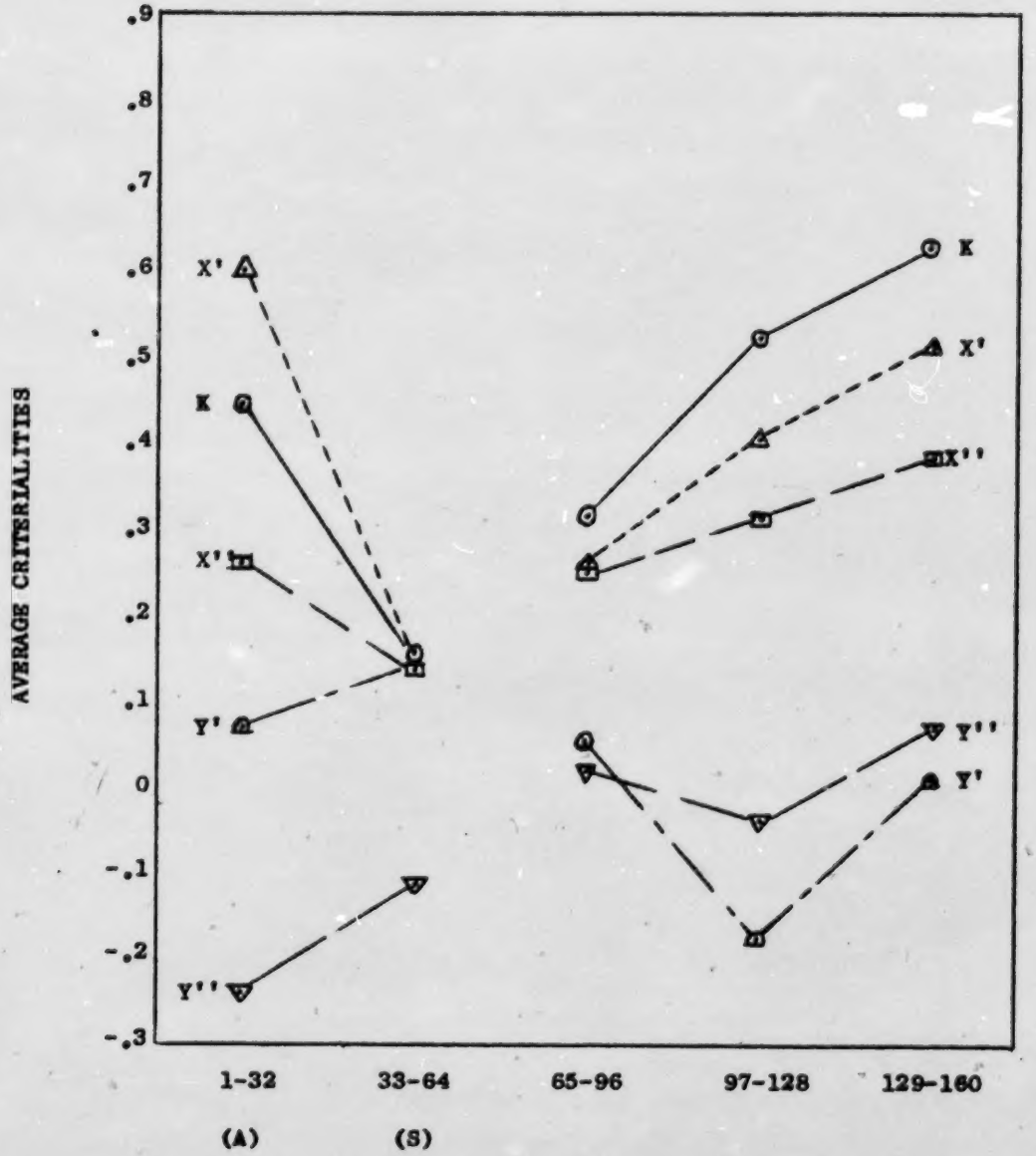

Fig. 3. Criterialities for Experimental Group 1 (MIN-MAX S)

In addition to the previous findings these indicate that:

1. All groups learned to ignore the irrelevant cues y' and y".

2. There was a general decrease in performance in going from an asynchronous to a synchronous block.

3. The gain in performance obtained when going from a synchronous block to an asynchronous block was greater than that obtained when going from a synchronous to another synchronous block.

4. The experimental groups weighted the relevant cues (x', x") more heavily than did the control group.

Questionnaire

After the 64th trial and again at the end of the experiment, the subjects were asked to assign 'k' values to four test stimuli and to indicate how they arrived at their answers. The amount of information which was obtained in this way was lexx than expected. The subjects found it difficult to verbalize their strategies or methods of solution. In fact, there were cases where S was close to the solution in terms of the performance measure (k-criteriality >. 85) and yet was able to express only a vague notion about the fact that the crosses appeared in columns with different weights.

Early hypotheses were generally specific to some area of the square; e. g., : "if both crosses are at the left side, k=3; if both crosses are at the right side, k=12." The notion of columns seemed to enter first, followed by the idea of differing weights for the two crosses. Also, subjects who had relatively sophisticated strategies, generally used the red cross as the main factor;e. g., : "get distance of the red cross from the right or left side of the square and then the distance of the green cross from the red cross."

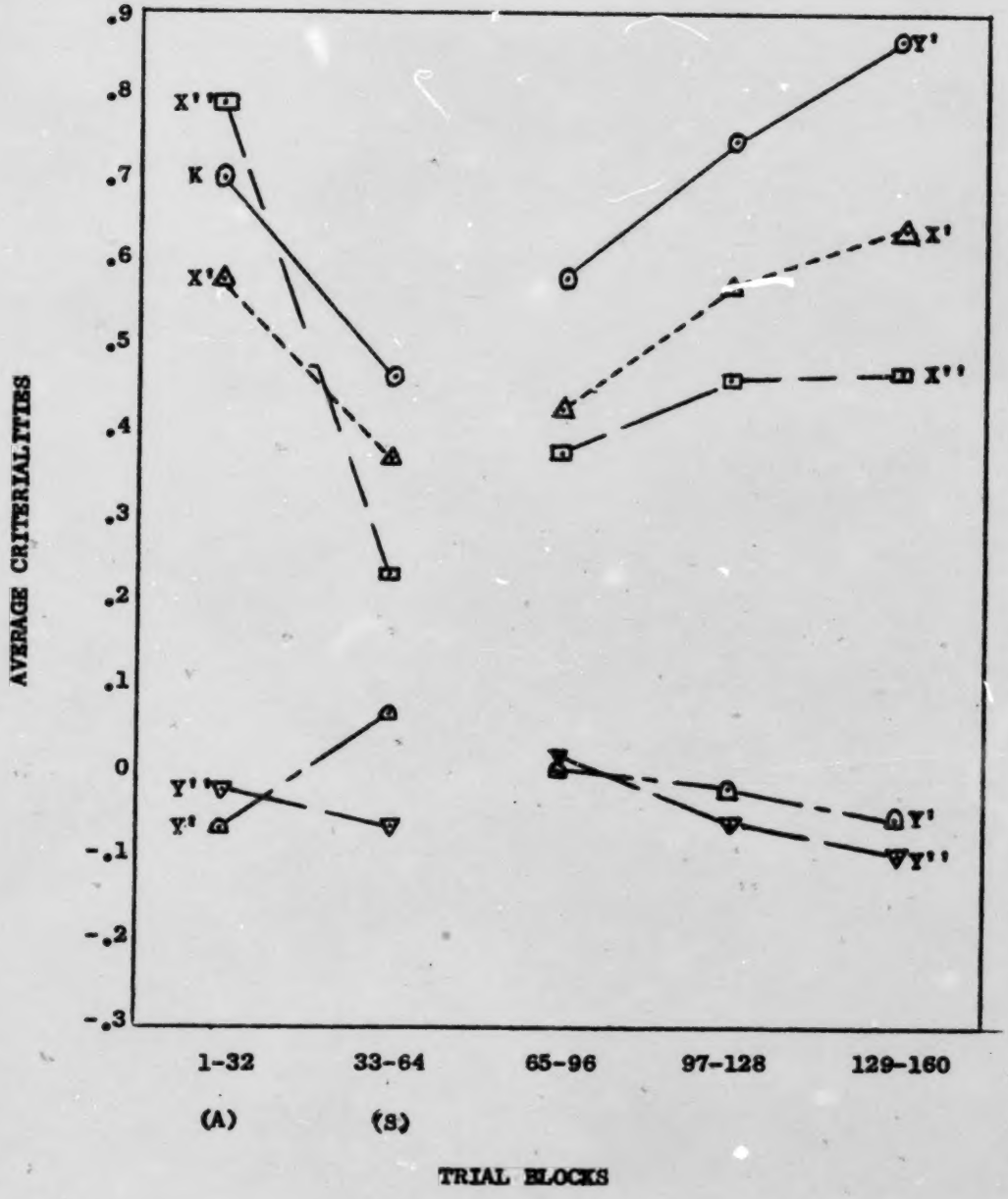

Fig. 4. Cue Criterialities for Experimental Group 2 (MAX-MIN, S)

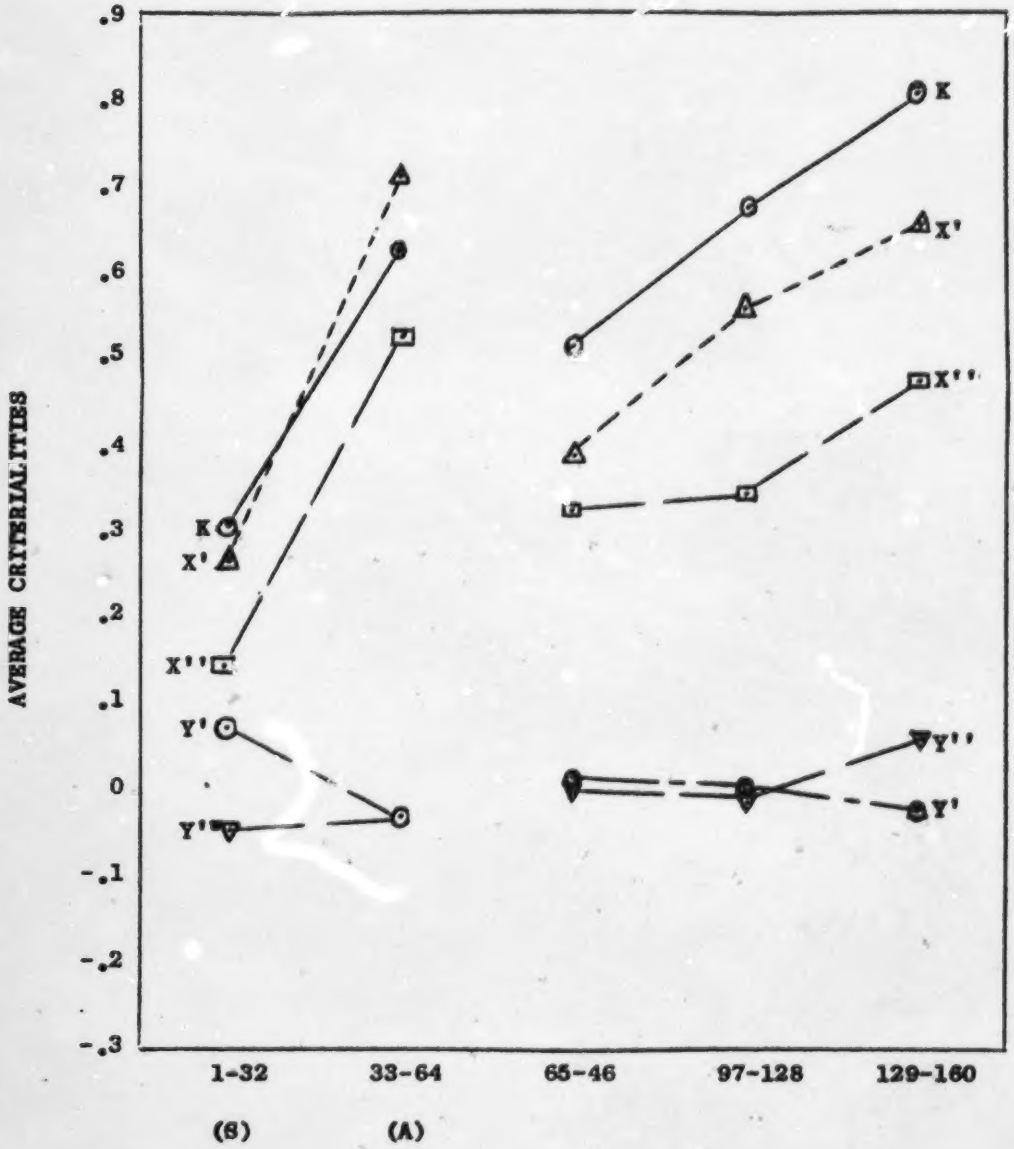

Fig. 5. Cue Criterialities for Experimental Group 3 (S, MAX-MIN)

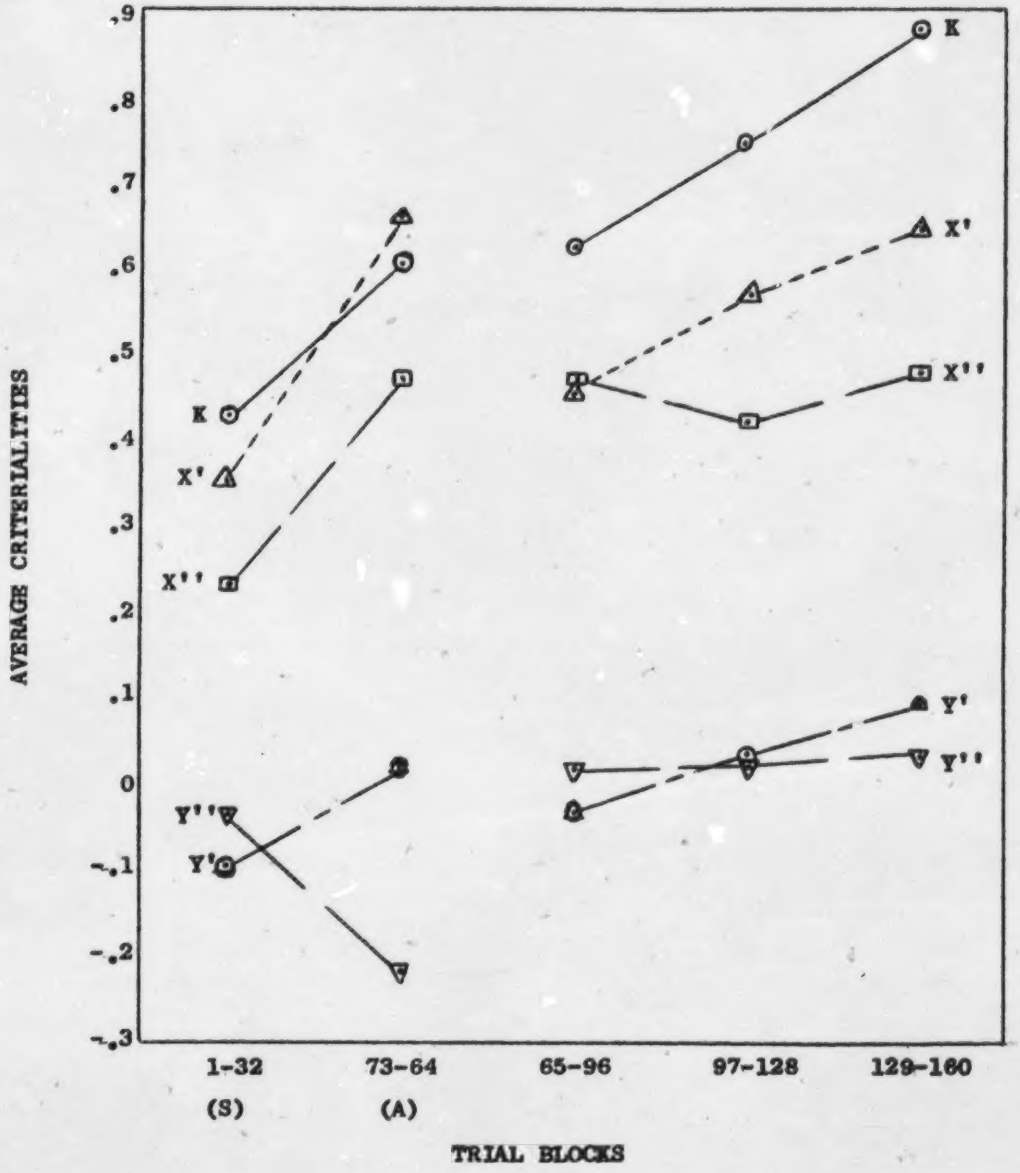

Fig. 6. Cue Criterialities for Experimental Group 4 (S, MAX-MIN)

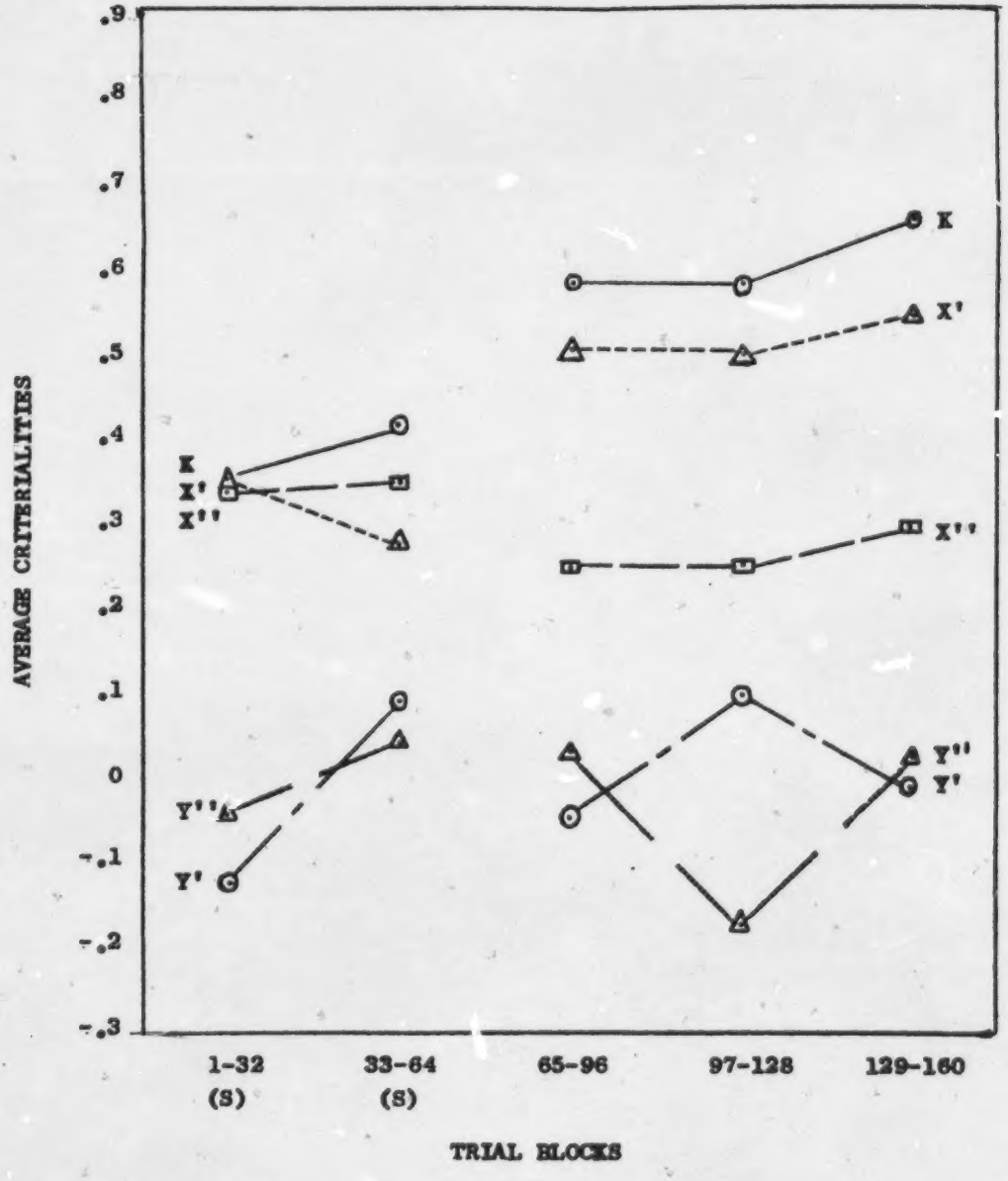

Fig. 7. Control Group Criterialities

DISCUSSION

The discussion is organized according to the questions listed on pages 2 & 3.

1. What is the effect of adding the asynchronous trials?

As expected, the performance on asynchronous trials was far superior to performance on synchronous trials during training (Table 4). This agrees with the findings of Detambel and Stolurow. However, there is no clear indication that the asynchronous groups performed better than the synchronous group on the transfer or task trials. Fig. 1 shows three of the experimental groups performing above the control group on the last block, but this difference was not statistically significant.

The lack of a significant improvement in task trial performance as a result of asynchronous training could be due to one of the following factors. First, the control group consisted of eight females and three males while the experimental groups had females only. Also, the control group experiment was administered by a different experimenter. It is felt, however, that these differences in procedure did not have a significant effect on the results. This is partially verified by the lack of differences among the three S groups on the first block (Table 7). However, the possibility exists that males perform better on this task, giving the control group an advantage over the experimental groups.

Second, if the subjects use relationships between the crosses, then allowing them to concentrate on one at a time should be of no help. From the questionnaire results it seems evident that the subjects generally used the position of each cross separately to arrive at their answers. Therefore, this explanation is tentatively discarded.

Third, this study can be discussed in terms of the single-problem training versus multiple-problem training issue. Morrisett and Hovland (1959) have shown that there are two factors which seem necessary to produce a high degree of transfer in multiple-problem training: (1) a high degree of learning must be achieved on each single problem; (2) several problems must be presented to insure learned generalization. Although the first factor was satisfied as indicated by asynchronous performance, it seems that the second was not. Each of the two types of asynchronous trials used could be considered to have been taken from a set of 16 types of asynchronous blocks (one for each of the 16 possible positions of the fixed cross). According to the findings of Morrisett and Hovland, training on several members of these sets is necessary before significant transfer can be obtained. Since the groups in this study were trained on only one member of the set of 16 possible A-MAX blocks and one member of the set of 16 possible A-MIN blocks, then transfer to the total problem situation was low.

Fourth, there is some evidence that the experimental groups tended to overweight the green cross or less pertinent cue in arriving at their results (see Fig. 3-7). All of the experimental groups had much higher x"-criterialities than the control group on the last block. Also, for three of the experimental groups, the x"-criteriality was greater than the validity of x" (the correlation of x" with k, which is about .45 on each block). This is evidence (although not conclusive in a statistical sense) that the A-MIN condition was actually detrimental in that it led to the over-use of the less pertinent cue.

The conclusion is that the asynchronous training did not significantly improve performance on the transfer task as a result of two factors:

(1) the lack of generalized learning set due to training on only one member of the class of asynchronous blocks.

(2) the over-emphasis of the less pertinent cue as a result of asynchronous training trials on which that cue was allowed to vary.

This is only a tentative conclusion since it results from only one study. However, it will be used as a working hypothesis for further research in this area.

2. What is the best order of presentation of the asynchronous (A) and synchronous (S) training trials?

As shown in Table 2 there is no significant difference due to the two orders of presenting asynchronous and synchronous blocks during training. It was expected that the S-A order would have an orienting effect similar to the effect of introductions and overviews prior to presenting detailed verbal reports. However, this was not demonstrated in this experiment.

The conclusion, then is that synchronous training prior to asynchronous training does not improve efficiency of transfer. Again, this is tentative, since the amount of prior synchronous training is probably critical. This factor should be examined carefully before an overall conclusion is made concerning the effect of initial synchronous training.

3. During the asynchronous trials is it better to present the more relevant cue varying first?

The answer to this question is "yes" since the groups which received A-MAX training first performed significantly better on the task trials than those which received A-MIN training first. This indicates that the order of training on complex tasks should proceed from the most pertinent aspects to the least pertinent aspects. Also, the second conclusion in the discussion of question 1 gives rise to the possibility that the amount of training should be lower for the less pertinent aspects.

FURTHER RESEARCH

The conslusions arrived at in this experiment will serve as the basis for future investigations. In particular, the following questions are of interest:

1. How does the type of asynchronous training affect transfer:

On the basis of this experiment it is expected that training which involves only maximally pertinent cues should be superior to that which involves only minimally pertinent cues.

2. How does the amount of asynchronous training affect transfer?

There are several issues here. First, there is the question of how much training should be given for each type of asynchronous block (fixed cross in a given position). Second, there is the question of how many types of asynchronous blocks should be presented for optimum transfer. These two questions relate to the multiple problem training issue as discussed by Morissett and Hovland.

Third, there is the question of apportioning training among the more pertinent aspects: Is it better to decrease the amount of training for the less pertinent aspects of a problem as compared with the more pertinent aspects? There is some slight evidence that this is the case. However, a direct test of this hypothesis is necessary before a definite conclusion can be made.

3. How does the order of asynchronous training affect transfer?

It was demonstrated in this experiment that transfer is greater when the more pertinent cue is allowed to vary first. This suggests that there is an order relationship in training which is based on the relevancy of the aspects. That is, the more relevant, or pertinent aspects should be presented first.

This should be demonstrated for the case of three or more aspects, each differing in their relevancy to the solution before this order effect is accepted.

SUMMARY

Several ways of structuring and sequencing the early trials of a complex task were compared. Four experimental groups received both structured (asynchronous) and unstructured (synchronous) training trials. The asynchronous trials were divided into two segments: A-MAX (the more relevant cue was free to vary) and A-MIN (the less relevant cue was free to vary.) The four experimental conditions were generated by the different sequential orders of presenting the structured and unstructured trials (A-S vs. S-A) as well as the two types of asynchronous trials (MAX-MIN vs. MIN-MAX). A control group received only synchronous training.

It was found that asynchronous training did not significantly improve performance. It is felt that this lack of improvement was due to the following two factors:

(1) the lack of generalized learning due to training on only one member of the class of asynchronous blocks.

(2) the over-emphasis of the less relevant cue.

For the experimental groups it was found that the presentation of synchronous training trials prior to asynchronous training did not improve performance. Therefore, the hypothesis that this would aid transfer by familiarizing subjects with the transfer task prior to synchronous training was not founded.

It was found that presenting a sequence in which the maximally pertinent cue varied first (A-MAX condition) led to improved transfer task performance. This is an indication that the order of training on a complex task should proceed from the more relevant to the less relevant aspects.

REFERENCES

Azuma, H. Comparison of a correlational with a probabilistic approach to concept learning. Urbana, Ill.: Univer. of Ill., Training Res. Lab., 1960. Unpublished doctoral dissertation.

Detambel, M. H. and Stolurow, L. M. Stimulus sequence and concept learning. J. exp. Psychol., 1956, 51, pp. 34-40.

Edwards, A. L. Experimental design in psychological research. New York: Rinehart & Company, Inc., 1960.

McHale, T. J. and Stolurow, L. M. Concept formation with metrically multi-valued cues and response categories. Urbana, Ill: Univer. of Ill., Training Res. Lab., Tech. Rep. No. 3, ONR 1834(36), April, 1962.

Morrisett, M. L. and Hovland, C. I.. A comparison of three varieties of training in human problem solving. J. exp. Psychol., 1959, 58, pp. 52-55.

Winer, B. J. Statistical principles in experimental design. New York: McGraw-Hill, 1962.

Appendix A

Cue Values During the Asynchronous Blocks

	Max Condition				Min Condition			
Trial	x'	y'	x"	y"	x'	y'	x"	y"
1	3	12	3	3	3	9	12	12
2	9	6					3	12
3	6	6					3	3
4	6	3					12	9
5	12	3					6	3
6	9	12					6	6
7	3	3					12	3
8	6	6					6	12
9	12	12					9	3
10	6	12					9	12
11	9	3					3	3
12	12	9					3	9
13	6	9					9	6
14	12	6					9	9
15	3	6					12	3
16	9	9					3	12

Appendix B

Intercorrelations of the Cues and K

A. Training Trials

Block

A-MAX		x'	y'	x''	y''
	k	1	-.026	0	0
	x'		-.026	0	0
	y'			0	0
	x''				0

A-MIN		x'	y'	x''	y''
	k	0	0	1	-.024
	x'		0	0	0
	y'			0	0
	x''				-.024

S_1 (first block of the control group)		x'	y'	x''	y''
	k	.894	-.050	.447	.117
	x'		-.023	.000	.113
	y'			-.138	.047
	x''				.038

S_2 (S block for the Exp. Groups, and S_2 block for the control)		x'	y'	x''	y''
	k	.894	.039	.447	-.034
	x'		.013	.000	-.025
	y'			.063	-.087
	x''				-.025

B. Task Trials

S_3 (65-96)		x'	y'	x"	y"
	k	.894	-.057	.447	.112
	x'		-.051	.000	.100
	y'			-.-26	-.077
	x"				.050

S_4 (97-128)		x'	y'	x"	y"
	k	.894	.063	.447	.022
	x'		.046	.000	-.025
	y'			.055	.114
	x"				.100

S_5 (129-134)		x'	y'	x"	y"
	k	.894	.045	.447	.047
	x'		.000	.000	.000
	y'			.100	.026
	x"				.105

Appendix C

INSTRUCTIONS TO STUDENTS

This task is designed to study your ability to learn to use relevant information to evaluate something. We will obtain a score showing how rapidly and how well you are able to use information in solving a problem which you do not completely understand from the beginning. It is to make evaluations we will call k-ness.

We are going to show you some drawings, and we want you to judge how much k-ness each figure has. We will tell you how to compute k later.

Turn to page one which has six figures on it. Each figure has a red cross and a green cross. The position of the red cross and green cross determine the value of k for each figure. Look at your answer sheet. For each item, there are ten possible answers: 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12. You are to figure out how to predict the k-scale value from information given you in each figure.

We will show you a series of figures, like the ones you see on page one. You are to decide the value of each on the scale; that is, you are to decide whether its k-value is 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12.

HOW TO USE YOUR ANSWER SHEET:

For each drawing there is one row on your answer sheet. That row contains ten numbers, which are the ten possible responses: 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12. After you decide how large k is for a figure, mark your answer by drawing an X through the proper number. You will be allowed 20 seconds for each figure. Twenty seconds sounds like too short a time, but you will find that it is sufficient. At the end of each 20-second period, I will tell you the correct answer for that item. You may underline the correct answers if you wish. Do not draw another X through the correct answer.

Remember:

1. You are to judge the k-value of each figure.

2. You then draw an X through the proper number on your answer sheet. You will be told the correct answer at the end of each 20-second interval. Ideally, you should be able to answer each item correctly.

Do not look at any page in the booklet of figures except the one you are working on at the moment. That is, do not look back or ahead. If you finish an item before the allotted 20-second interval is over, wait until its answer is given before proceeding on the next item.

Wait for the signal to begin.

Appendix D

Average Criterialities

Exp. 1 (MIN-MAX, S)

		BLOCKS					
		1-16 A-MIN	17-32 A-MAX	33-64 S	65-96 S	97-128 S	129-160 S
	k	.261	.603	.155	.318	.523	.632
	x'	0	.603	.152	.261	.408	.511
variable	y'	0	.071	.140	.053	-.172	.010
	x"	.261	0	.145	.253	.315	.388
	y"	-.436	0	-.110	.022	-.040	.069

Exp. 2 (MAX-MIN, S)

		1-16 A-MAX	17-32 A-MIN	33-64 S	65-96 S	97-128 S	129-160 S
	k	.586	.793	.468	.589	.743	.863
	x'	.586	0	.378	.432	.577	.643
variable	y'	-.061	0	.074	-.049	-.015	.005
	x"	0	.793	.239	.379	.464	.476
	y"	0	-.021	-.053	-.099	-.055	.016

Exp. 3 (S, MIN-MAX)

		1-32 S	33-48 A-MIN	49-64 A-MAX	65-96 S	97-128 S	129-160 S
	k	.304	.522	.710	.511	.672	.803
	x'	.268	0	.710	.390	.559	.658
variable	y'	.071	0	-.036	.015	.003	-.023
	x"	.148	.522	0	.327	.343	.476
	y"	-.046	-.031	0	.001	-.010	.062

Exp. 4 (S, MAX-MIN)

BLOCKS

	1-32	33-48	49-64	65-96	97-128	129-160
	S	A-MAX	A-MIN	S	S	S
k	.427	.660	.472	.621	.747	.878
x'	.355	.660	0	.453	.568	.648
variable y'	-.087	.023	0	-.033	.036	.097
x''	.232	0	.472	.461	.421	.480
y''	-.032	0	-.218	.016	.028	.038

Control Group

	1-32	33-64	65-96	97-128	129-160
	S	S	S	S	S
k	.350	.413	.578	.574	.652
x'	.351	.272	.500	.494	.540
variable y'	-.124	.089	-.050	.096	-.009
x''	.336	.343	.244	.246	.297
y''	.046	.041	.229	-.174	.020